Higgs search in TauTau final states @ CMS

Simone Gennai (CERN/INFN)
on behalf of the CMS Collaboration

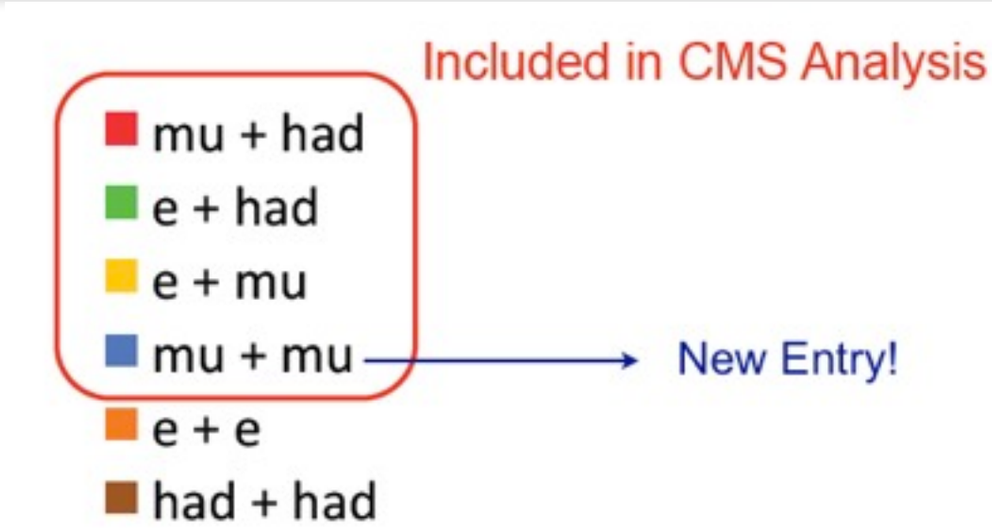
Outline

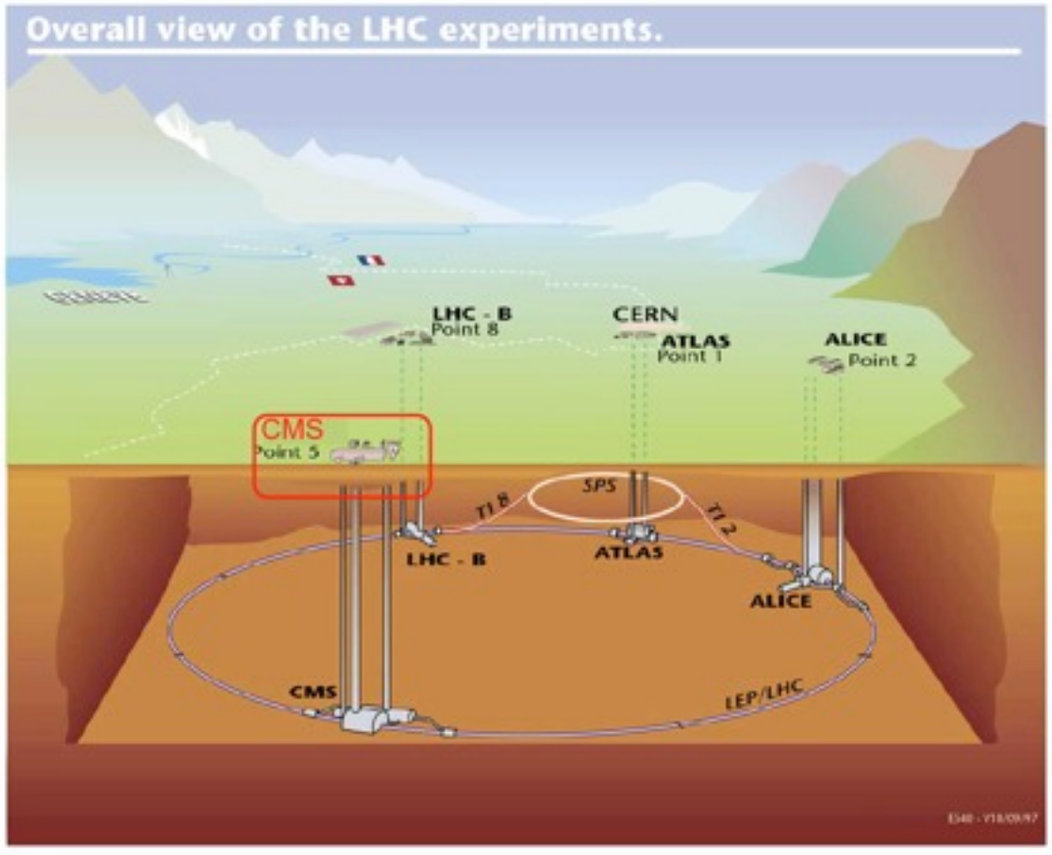
- Analyzed data
- Signal processes
- Event Categorization
- Tau ID
- Event selection
- Invariant mass distribution
- Limits
  - Reference: PAS-HIG-11-009

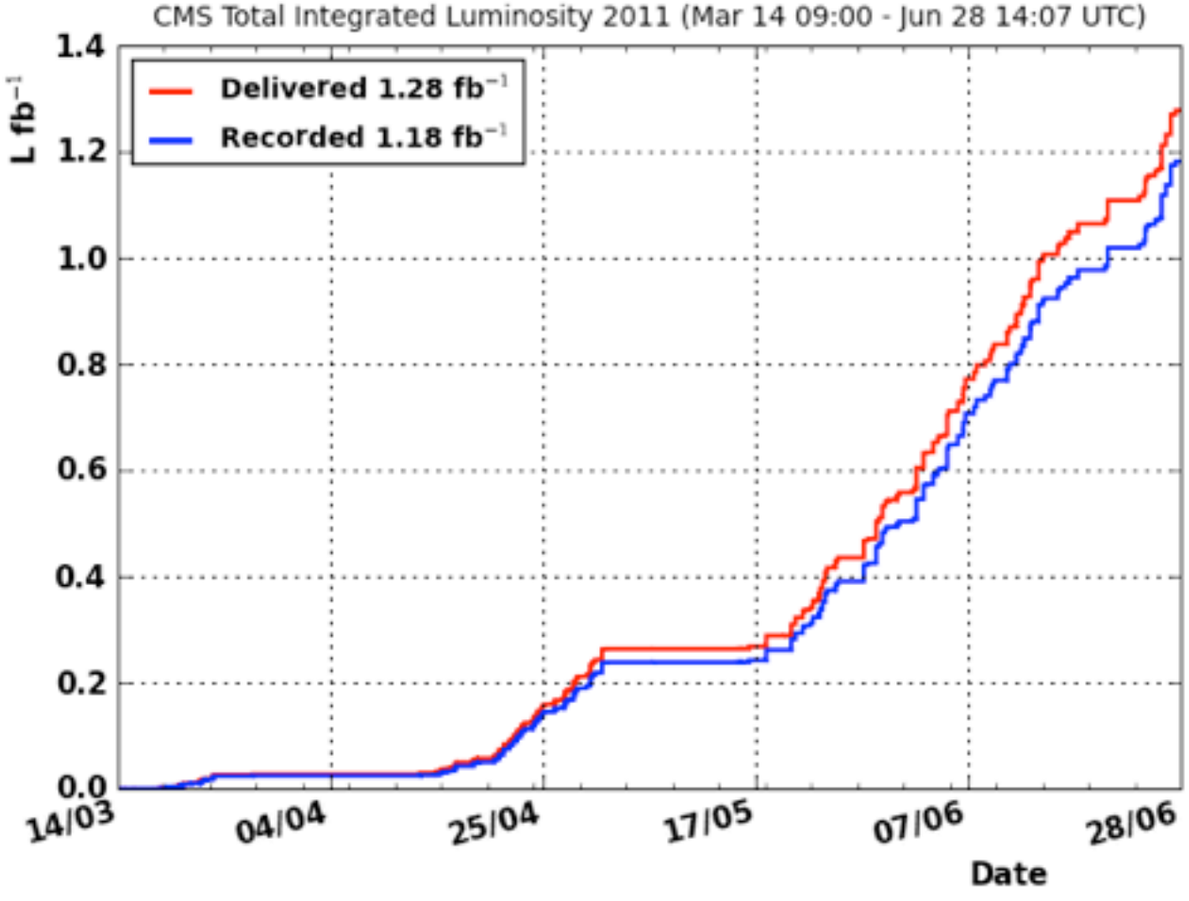
Simone.Gennai@cern.ch

Collected/Analyzed Data

- Data delivered by LHC : 1.28 fb^{-1}
- Data recorded by CMS : 1.18 fb^{-1}
  - about 92%
- High quality data : 1.1 fb^{-1}
  - about 93%
- Analyzed data 1.1 fb^{-1}

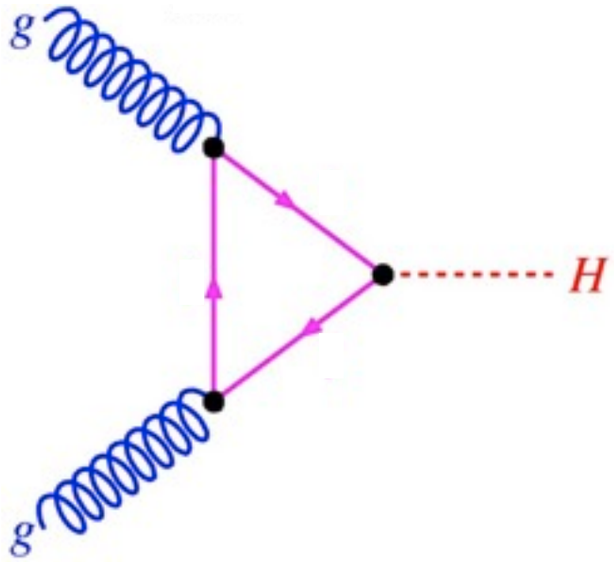


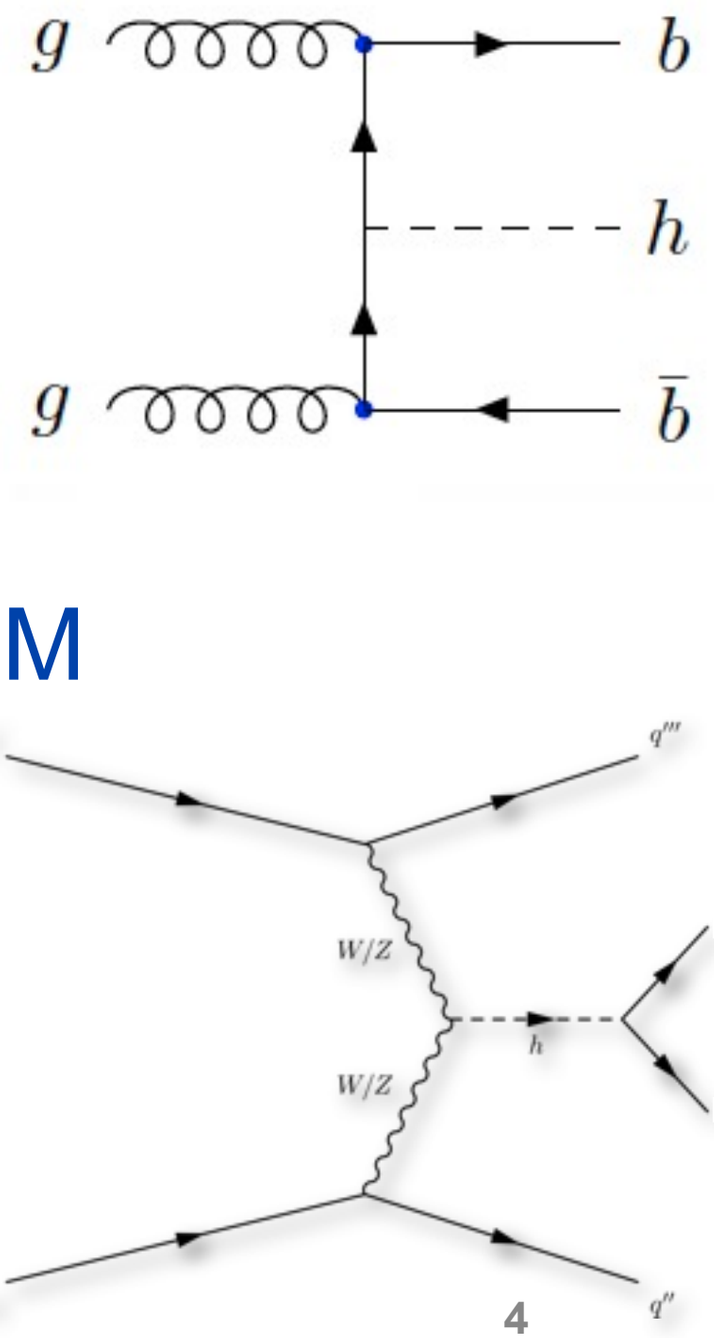


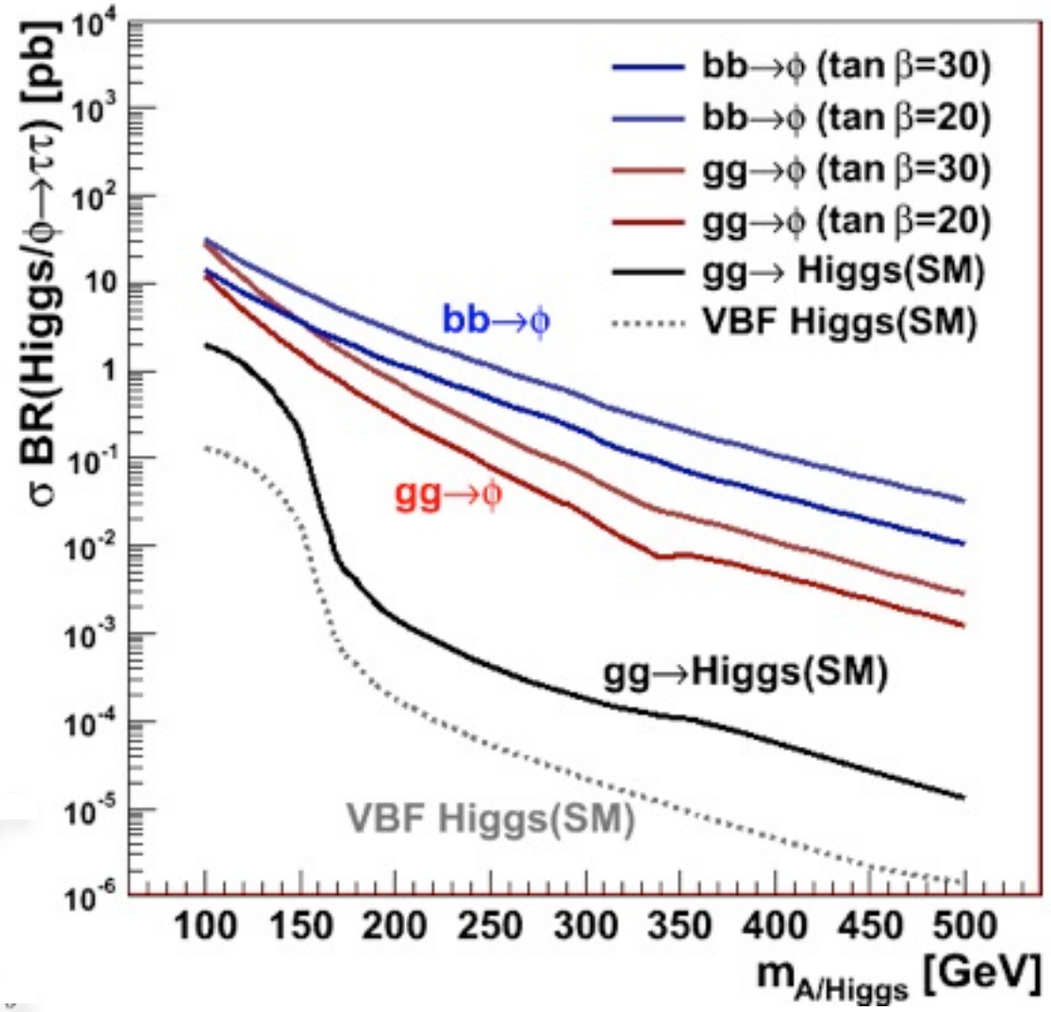


Production Mechanism

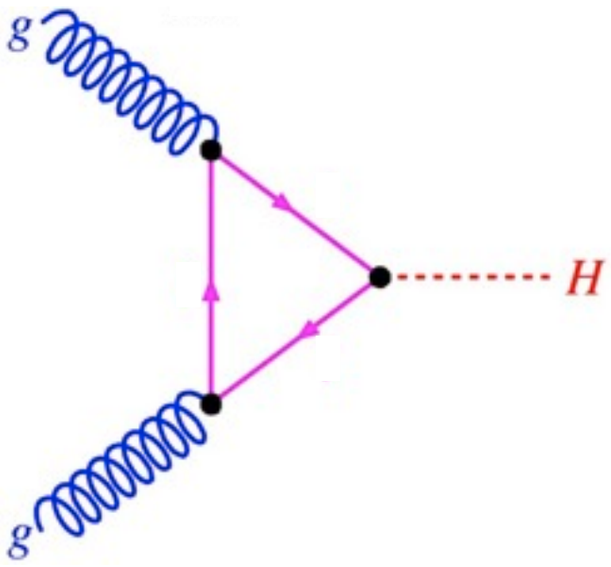
MSSM







SM



Simone.Gennai@cern.ch

Categorization

- limit based on the fit of the visible mass distribution
  - to gain sensitivity event categories on the basis of extra jets

Standard Model

VBF

Jets (pT > 30 GeV) = 2
AND
VBF selections(*)

NOT VBF

Jets (pT > 30 GeV) < 3
OR
Fails VBF selections

MSSM

bTagging

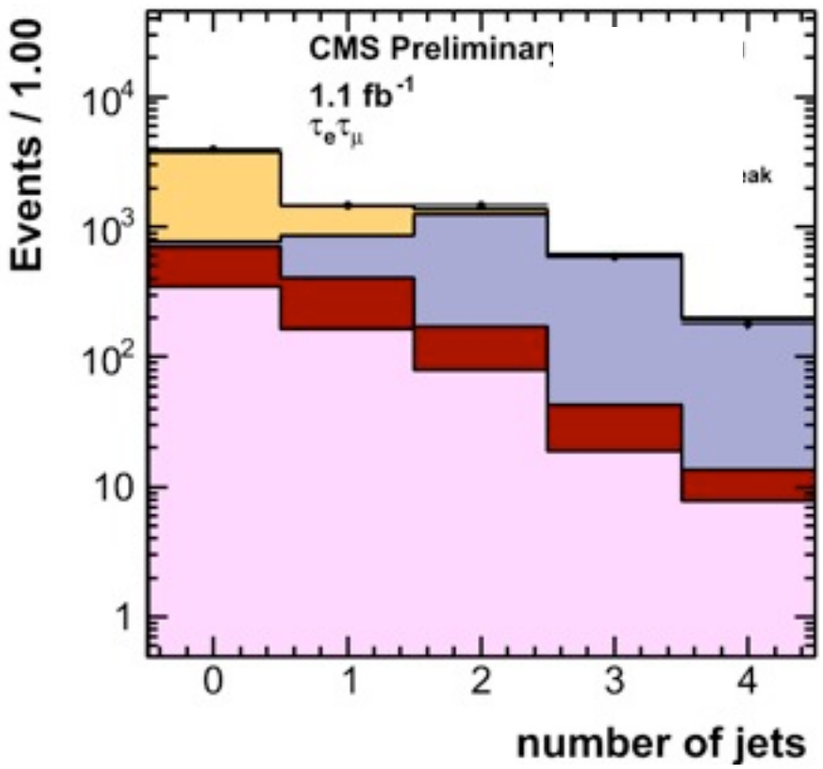
Jets (pT > 30 GeV) < 2
AND
btagged jets (pT > 20 GeV) > 0

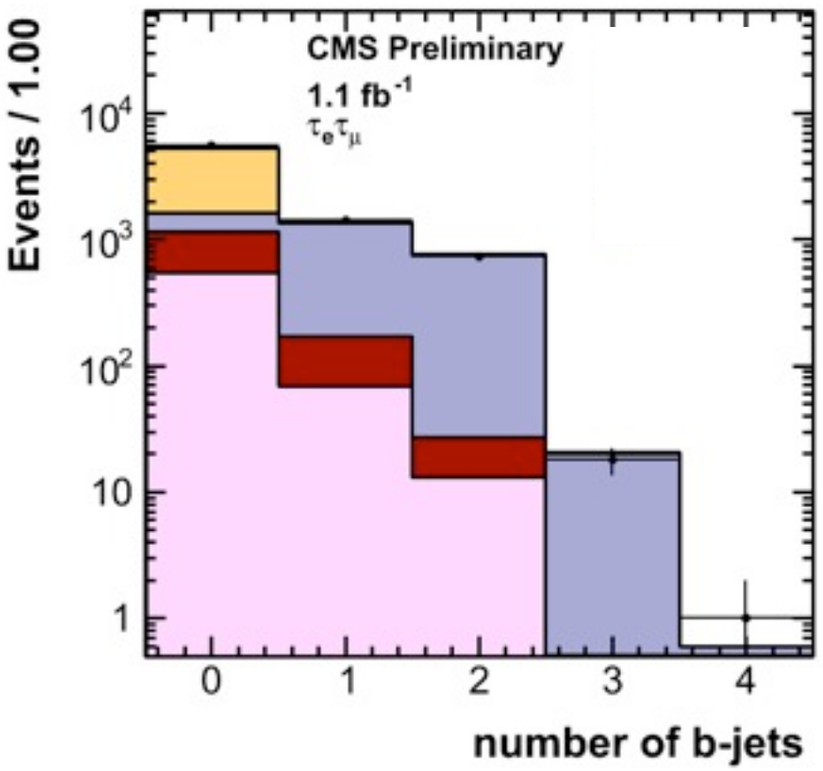
NOT bTagging

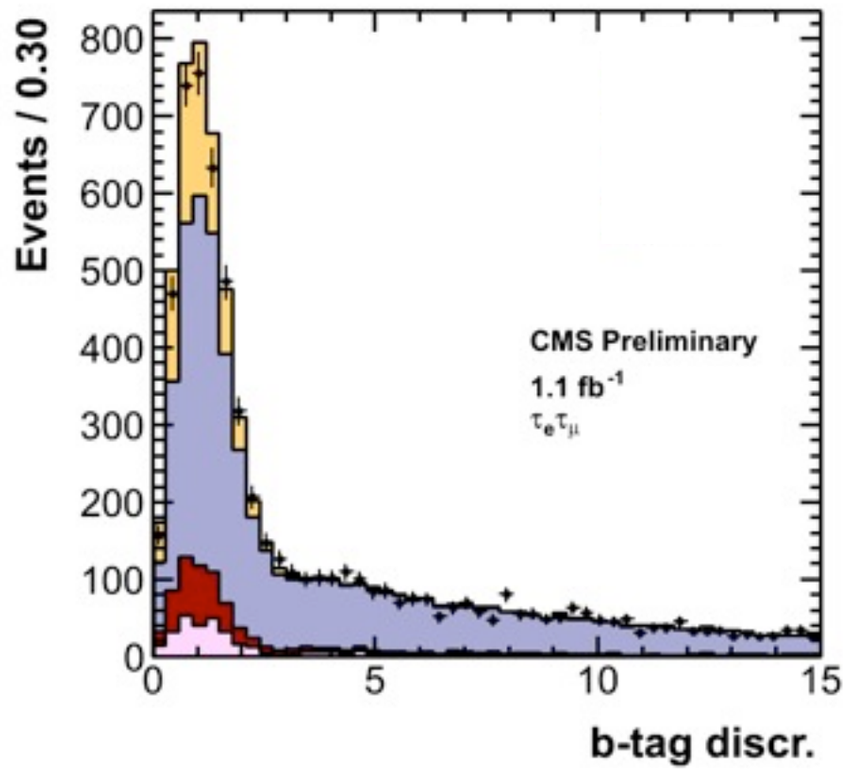
Jets (pT > 30 GeV) < 2
AND
btagged jets (pT > 20 GeV) = 0

* VBF : Mjj > 350 GeV, DeltaEtajj > 3.5, eta_j1 * eta_j2 > 0

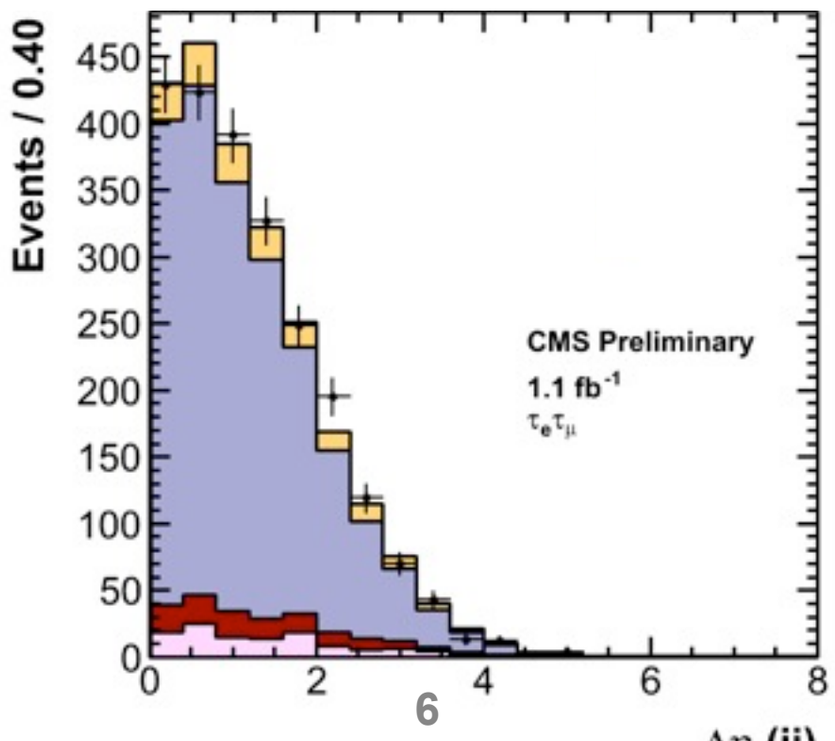
Jet variables

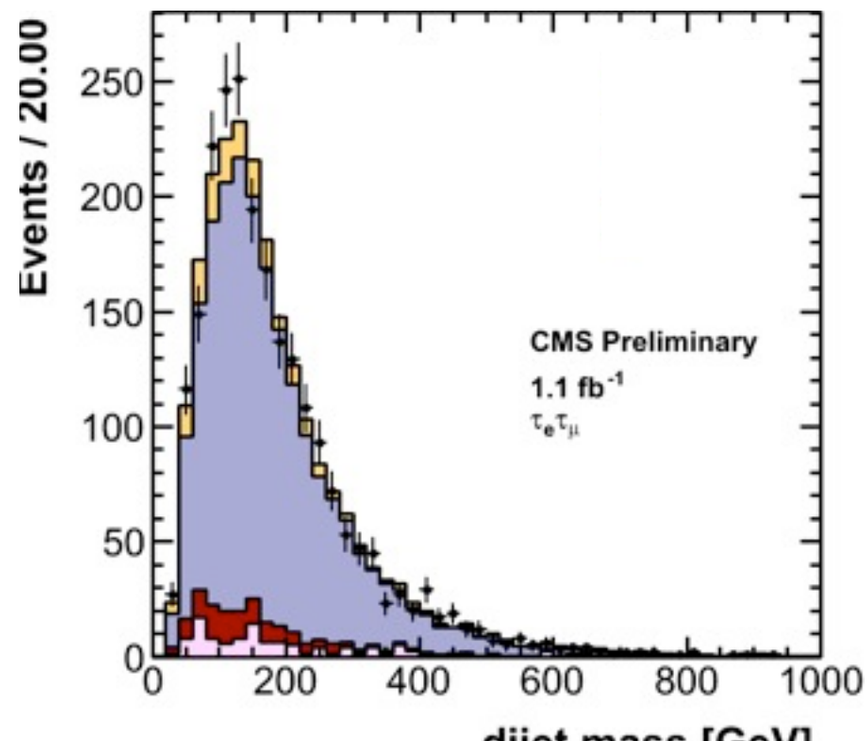






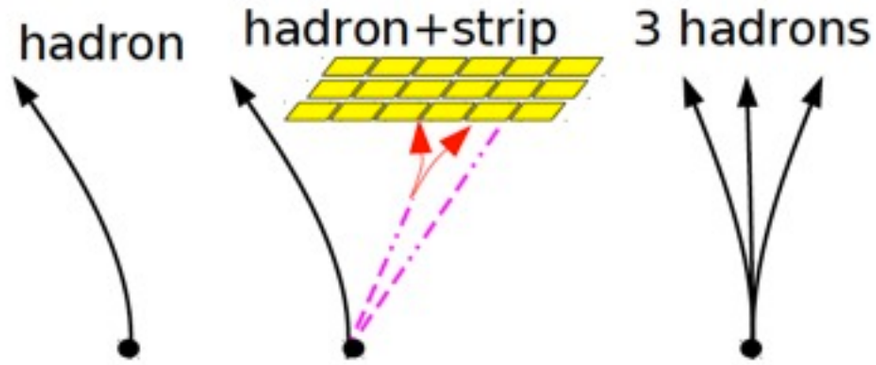
Observed
Z→ττ
tt̄
Electroweak
Fakes

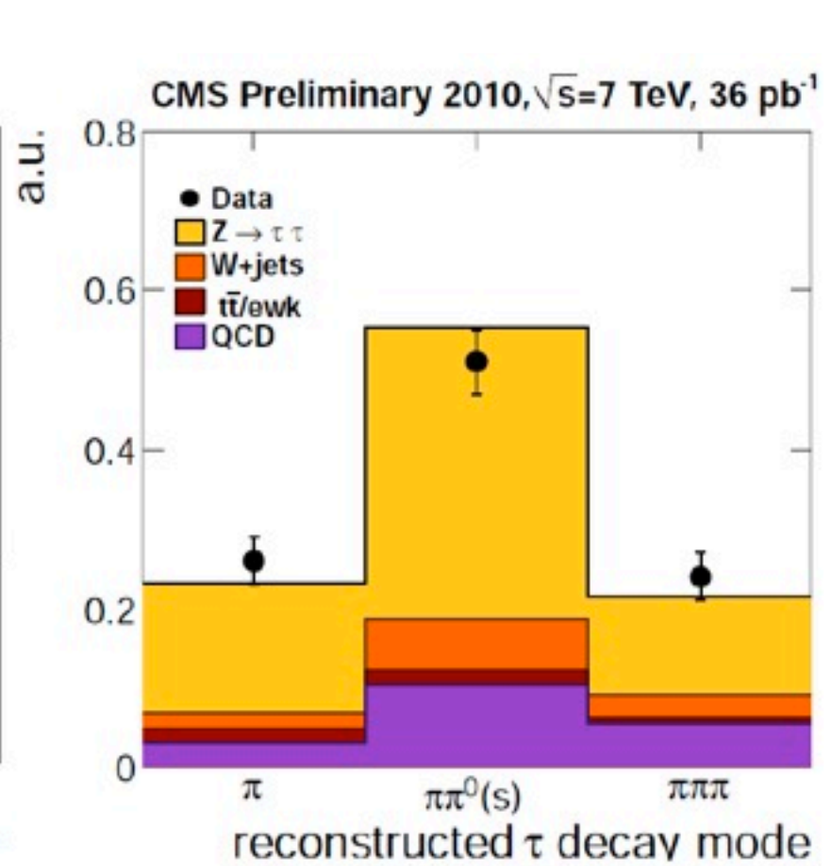


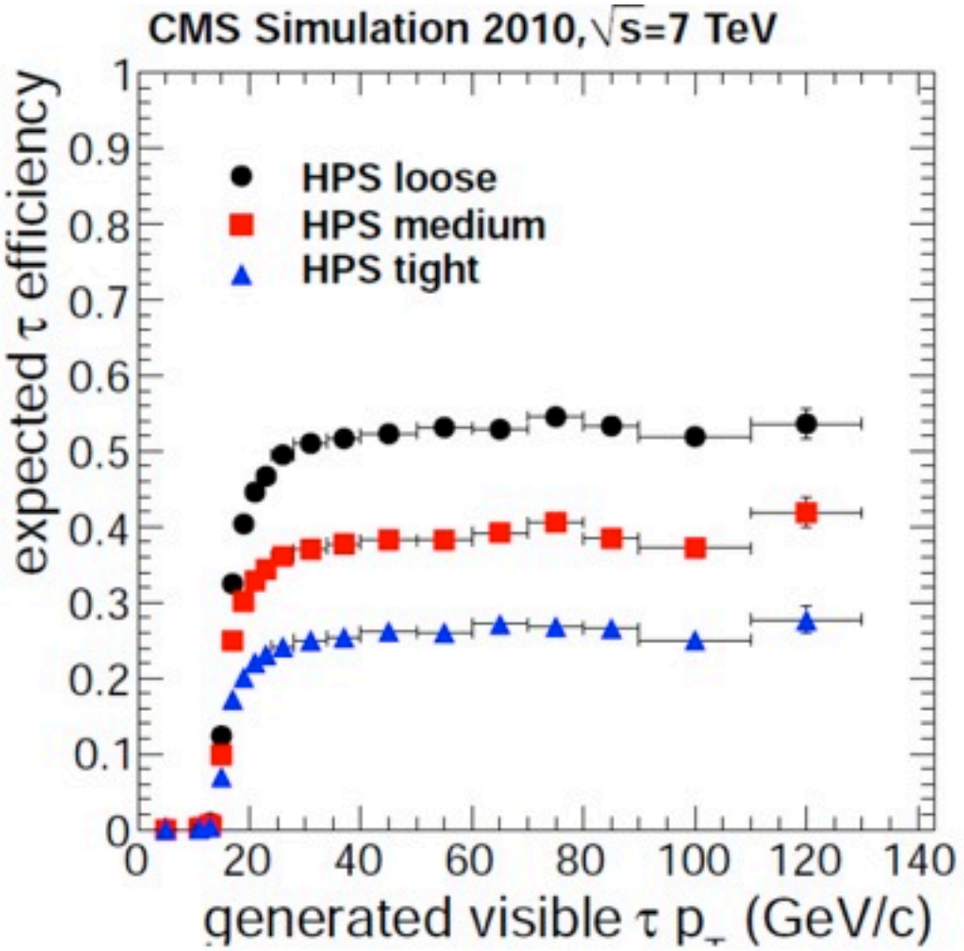


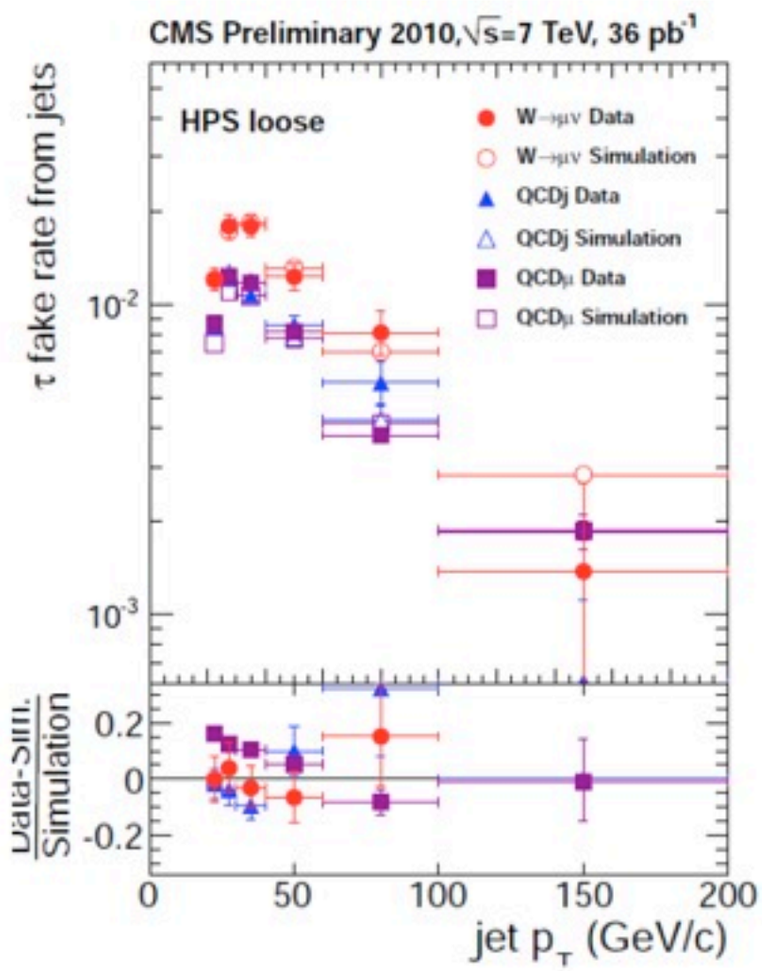
Hadronic Tau identification

- Reconstruction of the decay modes :
  - 1 prong, 1 prong + pi0's, 3 prongs
- Various working points for the isolation
- additional selections to reject electrons and muons

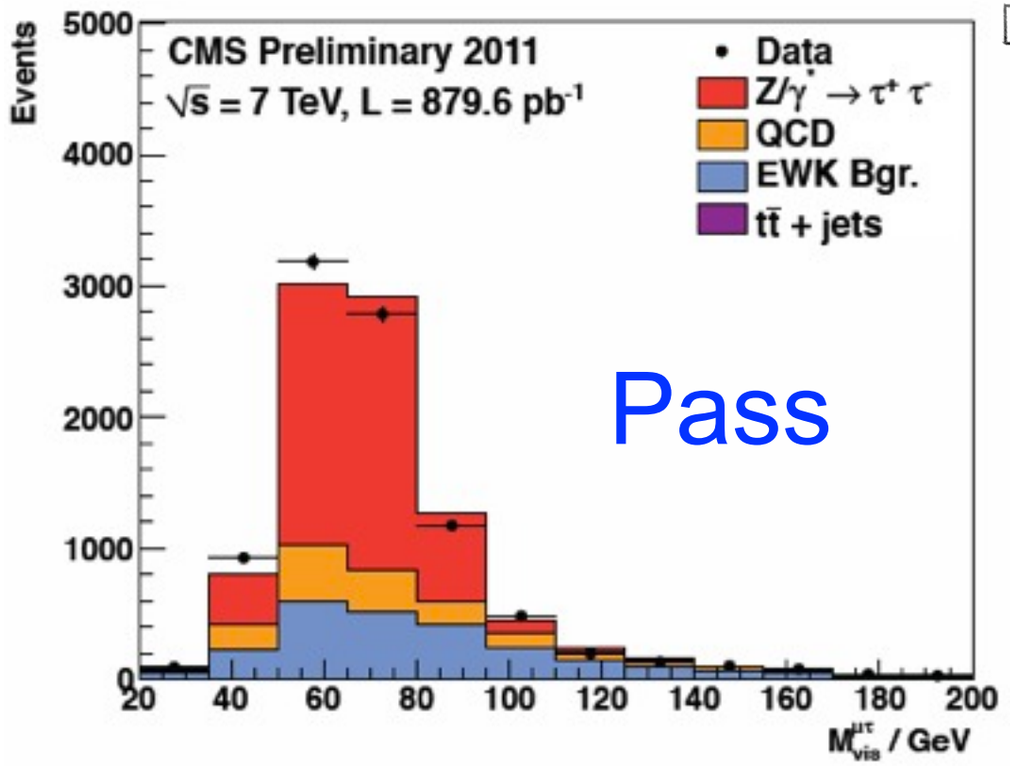


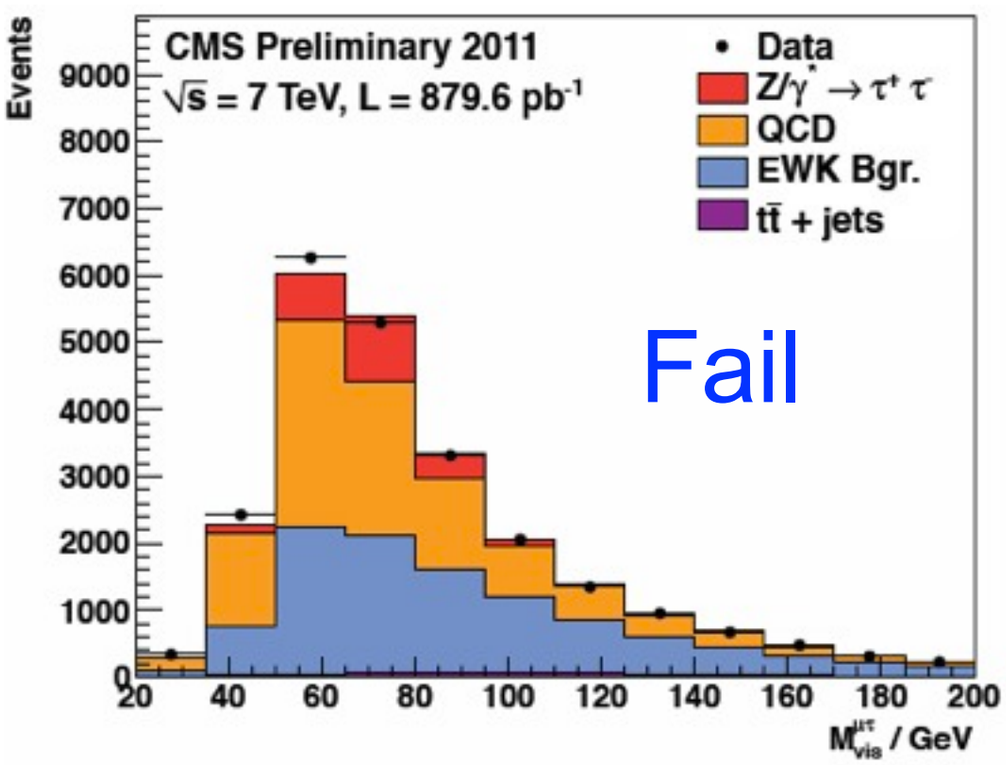






Tau ID efficiency





- Improved tau ID using Tag & Probe
  - BKG constrained from sidebands
    - See Mauro Verzetti poster for more information

Uncertainty's source	
Muon Momentum Scale	<< 1%
τ-Jet Energy Scale	< 1%
Track Reconstruction	3.9%
Track Momentum Scale	< 1%
Lead. Track P_T Cut	1%
Loose Isolation	2.5%
Jet → τ_{had} Fakes	1.2%
Lead. Track Corr. Factor	1.7%
Loose Iso. Corr. Factor	2.1%
Fit (Statistical Uncertainty)	2.6%
Total uncertainty	6%

New! (was 23% for Winter conferences)

Simone.Gennai@cern.ch

Event selections

- Standard CMS Jet/MET/lepton reconstruction and selection
- Acceptance cuts:

Mu+Tau

Muon pT > 15 GeV, |eta| < 2.1
and
Tau pT >20 GeV, |eta| < 2.3

Ele+Tau

Ele pT > 20 GeV, |eta| < 2.1
and
Tau pT >20 GeV, |eta| < 2.3

Mu+Ele

Muon pT > 20 (10) GeV, |eta| < 2.1
and
Ele pT > 10 (20) GeV, |eta| < 2.5

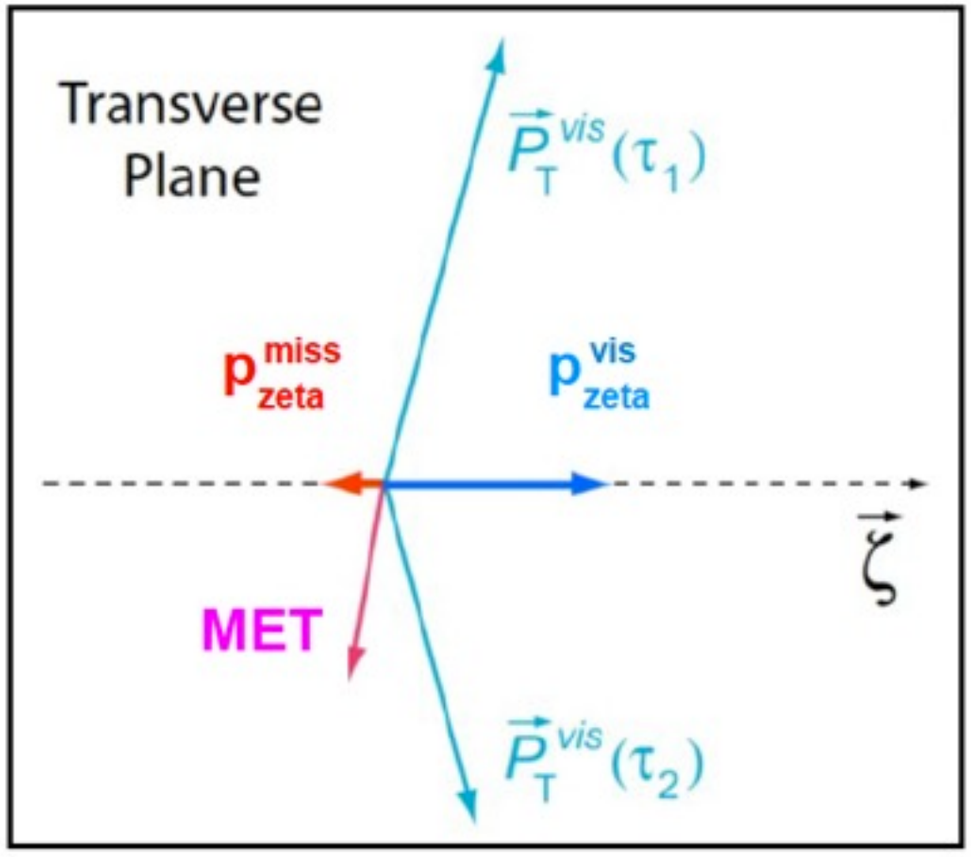
Mu+Mu

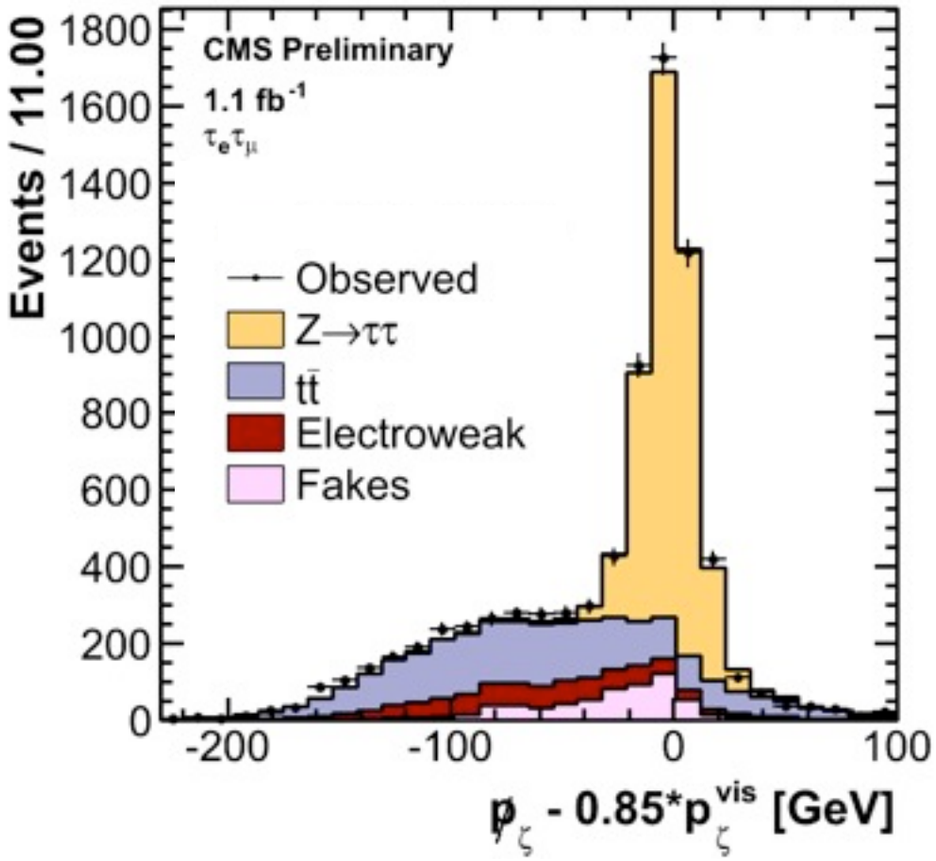
Lead muon pT > 20 GeV, |eta| < 2.1
and
Second muon pT > 10 GeV, |eta| < 2.4

Simone.Gennai@cern.ch

Topological cuts

- Leptons are required to have opposite charge
- e/mu+Tau and e+mu
  - Pzeta variable (“imported” from CDF) to suppress W+Jets
- mu+mu
  - MET < 65 GeV
  - likelihood based selections using MET and muons related information





Background estimation

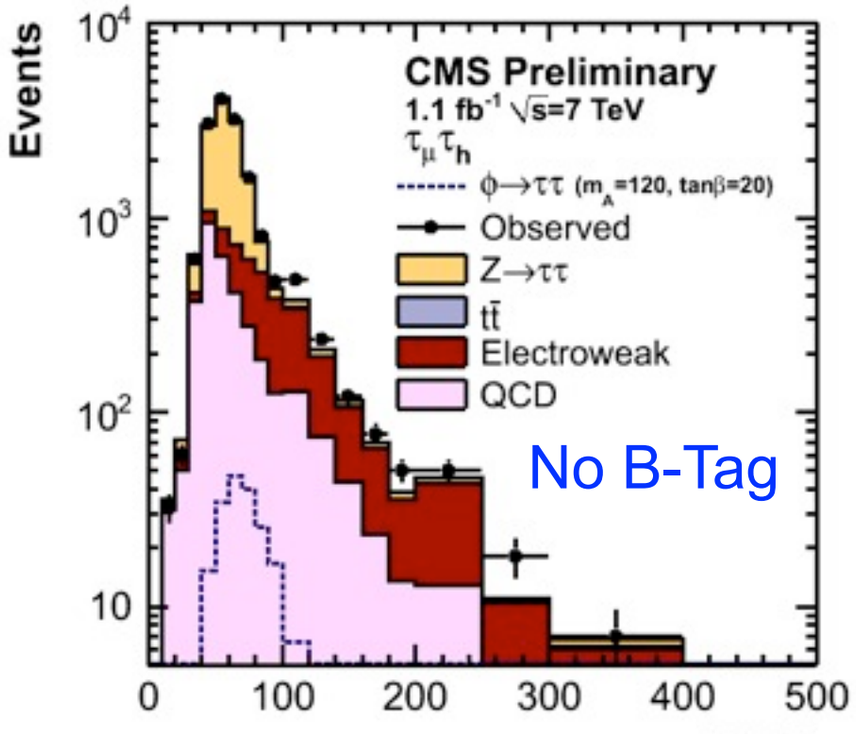
- Data Driven
  - QCD (mu+Tau, e+Tau)
  - Fake electrons bkg (e+mu)
  - Z->mumu (mu+mu)
- MC shape + sidebands normalization
  - Z->TauTau
  - TTbar
  - W+Jets (mu+Tau, e+Tau, e+mu)
- Pure MC
  - WW/ZZ/WZ

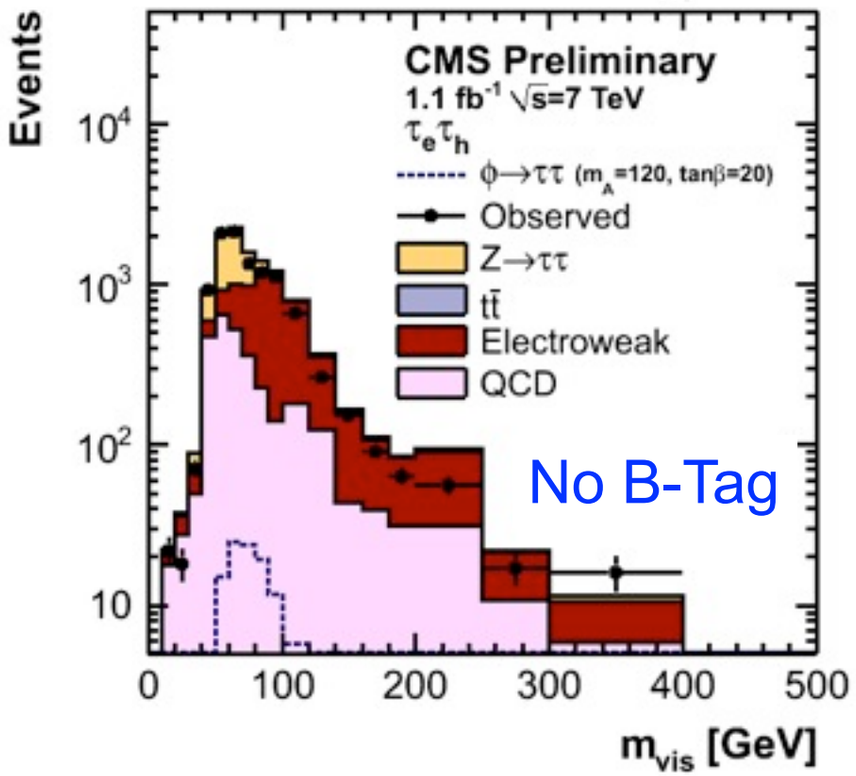
Uncertainties table

Source	Uncertainty	Usage
Lepton ID /trigger	**1%**	**Efficiency correction factors**
Tau ID efficiency	6%	Efficiency correction factors
Tau energy scale	**3%**	**Shape uncertainties**
σ(Z → μμ/ee)	**3%**	Z → ττ yield normalization
σ(ttbar)	12%	TTBar yield normalization
B-Tag Efficiency	10%	Correction factors
B-Tag Mistag rate	14%	Correction factors
Jet energy scale	2-5%	JEC in acceptance for BTagging/VBF
PDFs	3%	Uncertainty in cross section
UE/Parton Shower	4%	Uncertainty in cross section
QCD Scale	4-12%	Uncertainty in cross section
Luminosity	6%	

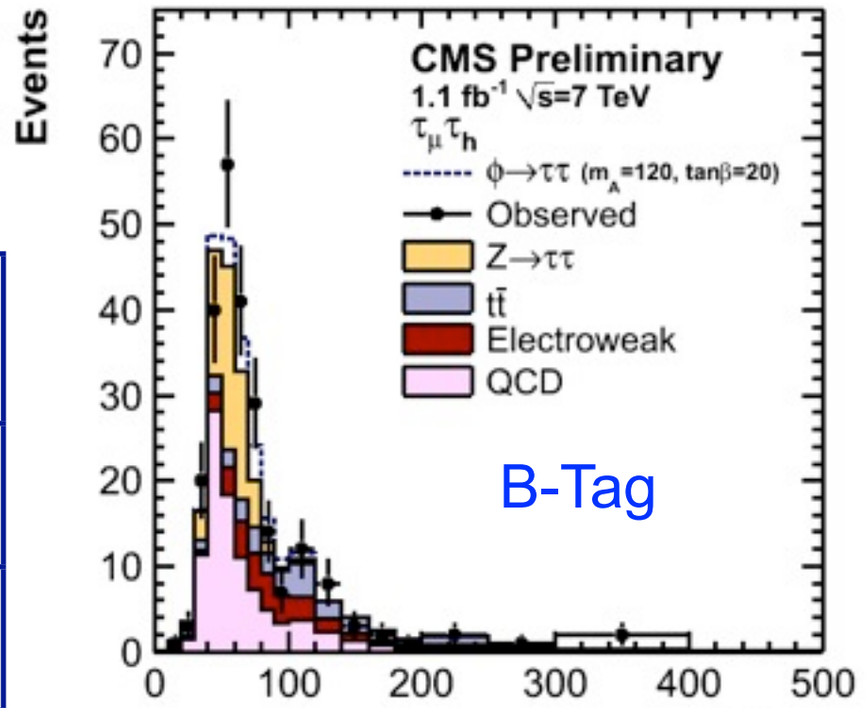
MSSM

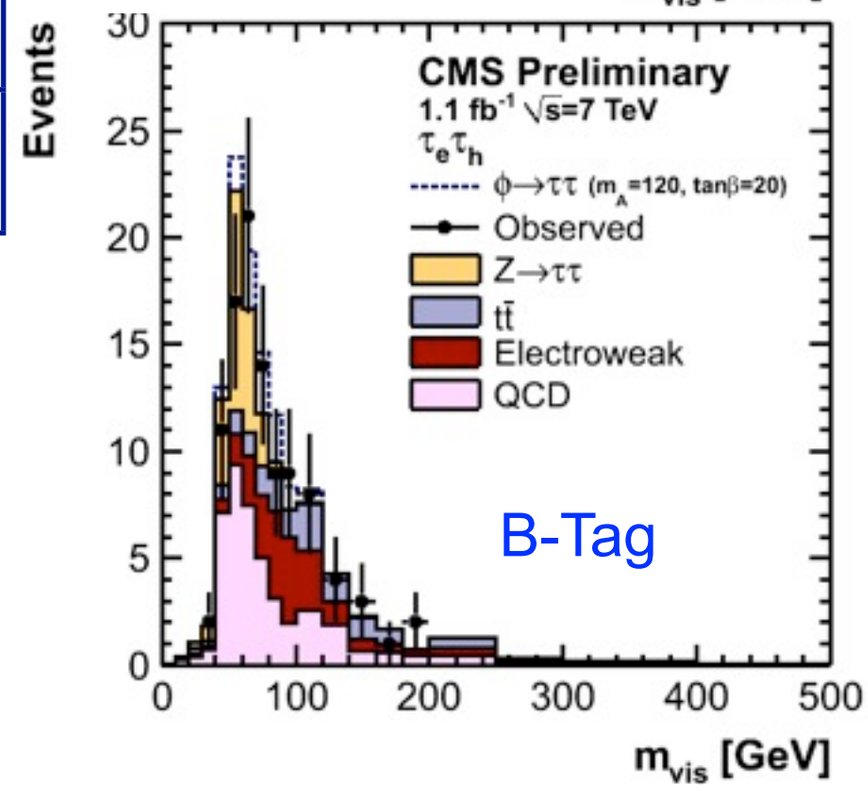
e/mu+Tau mass distributions



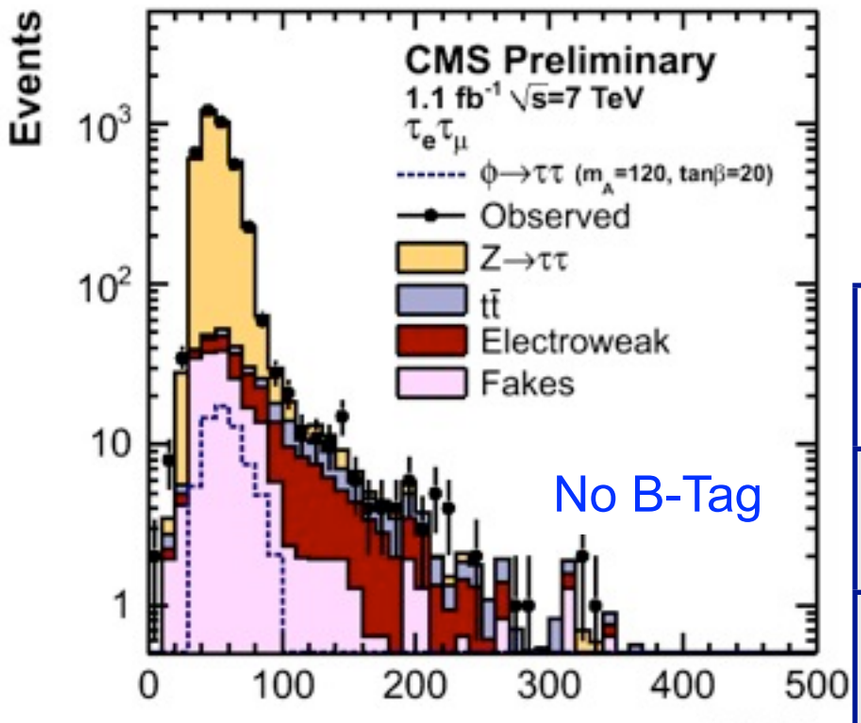


final state	No Btag	BTag
mu+Tau Bkg	14514 +- 640	193 +- 13
mu+Tau Data	15057	243
e+Tau Bkg	9398 +- 320	105 +- 9
e+Tau Data	10283	101

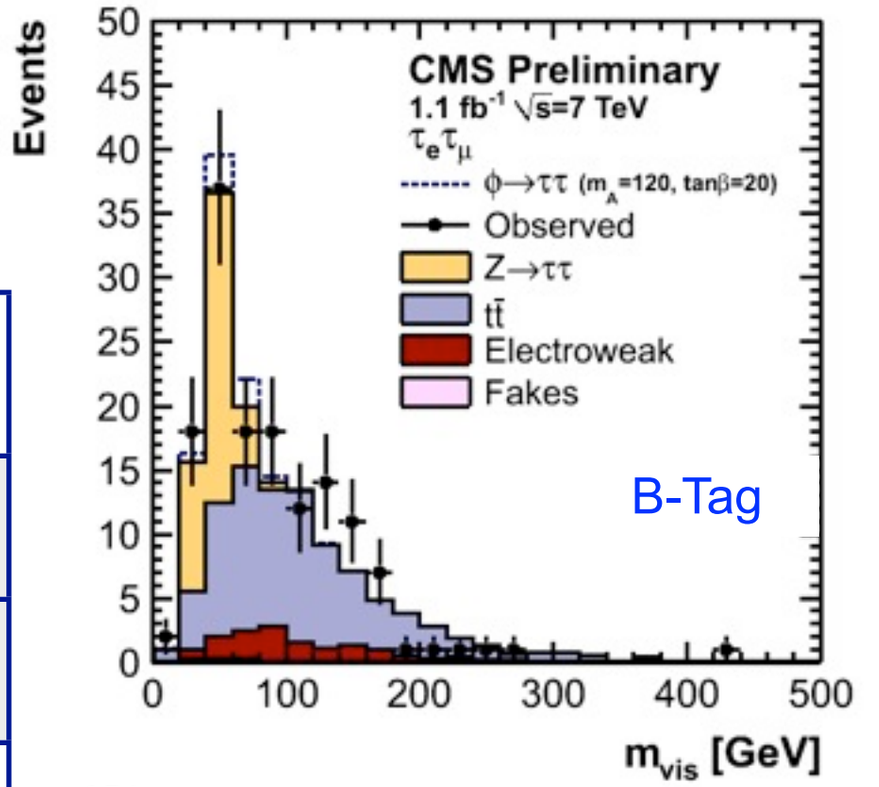


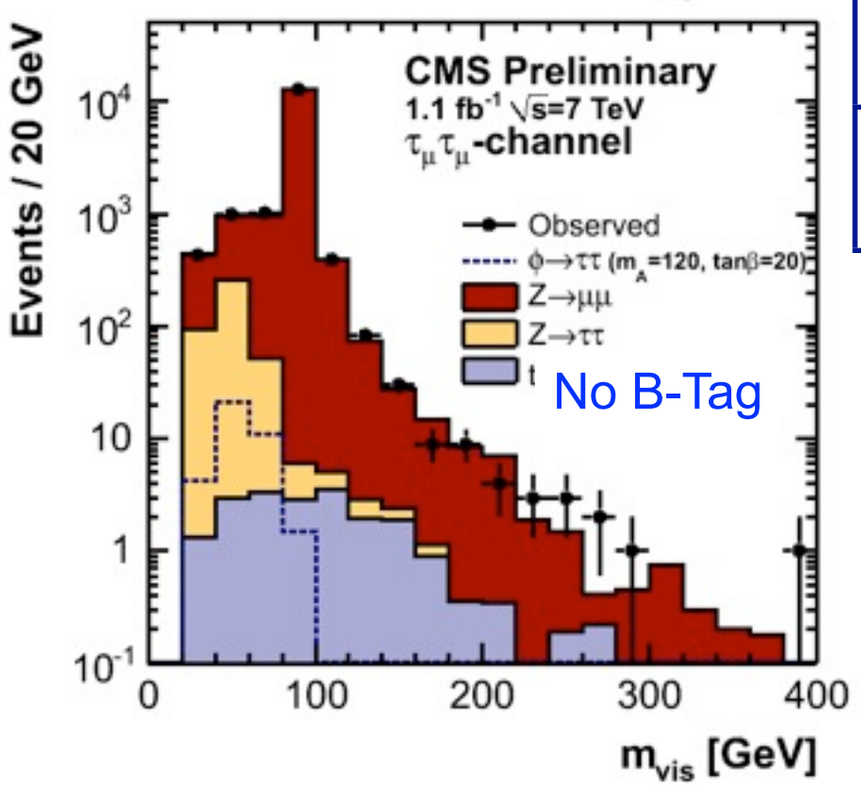


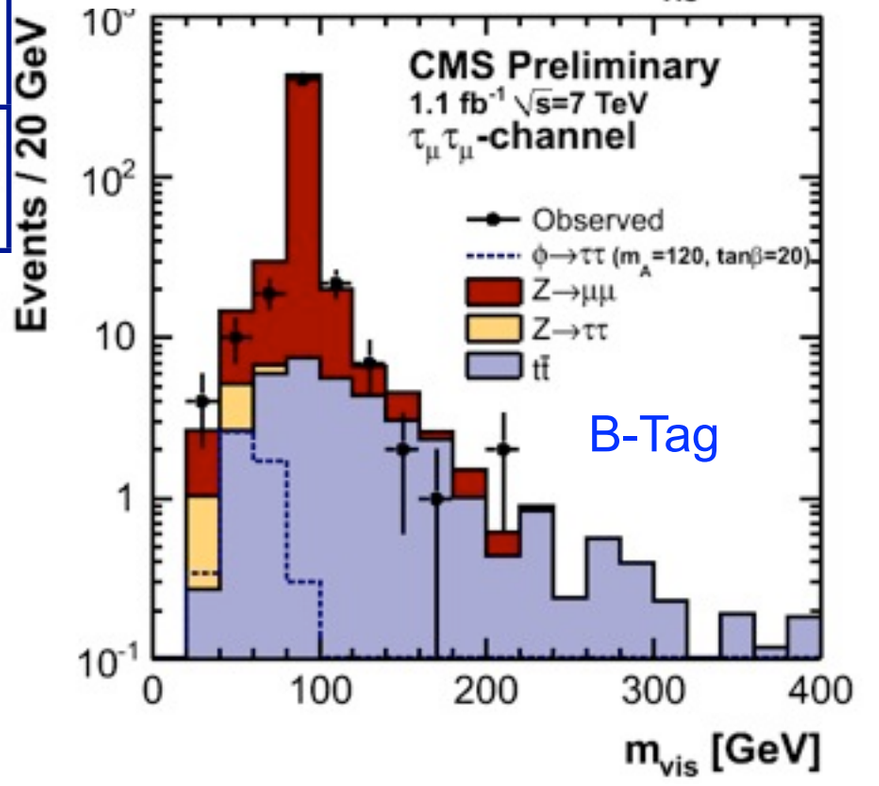
e/mu+Tau mass distributions

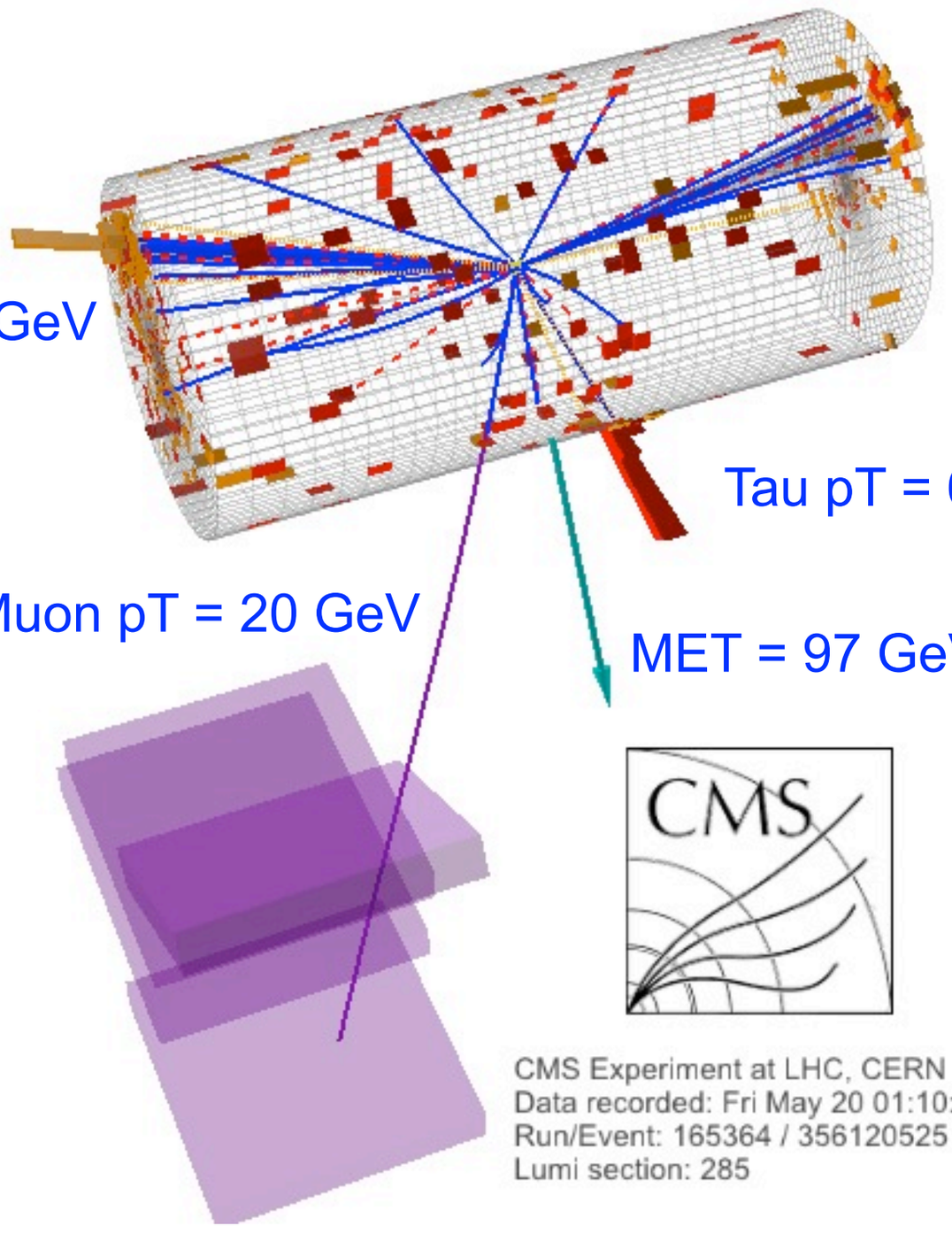


final state	No Btag	BTag
e+mu BKG	3643 +- 131	150 +- 12
e+mu Data	3942	143
mu+mu BKG	15645 +- 105	460 +- 12
mu+mu Data	15711	479



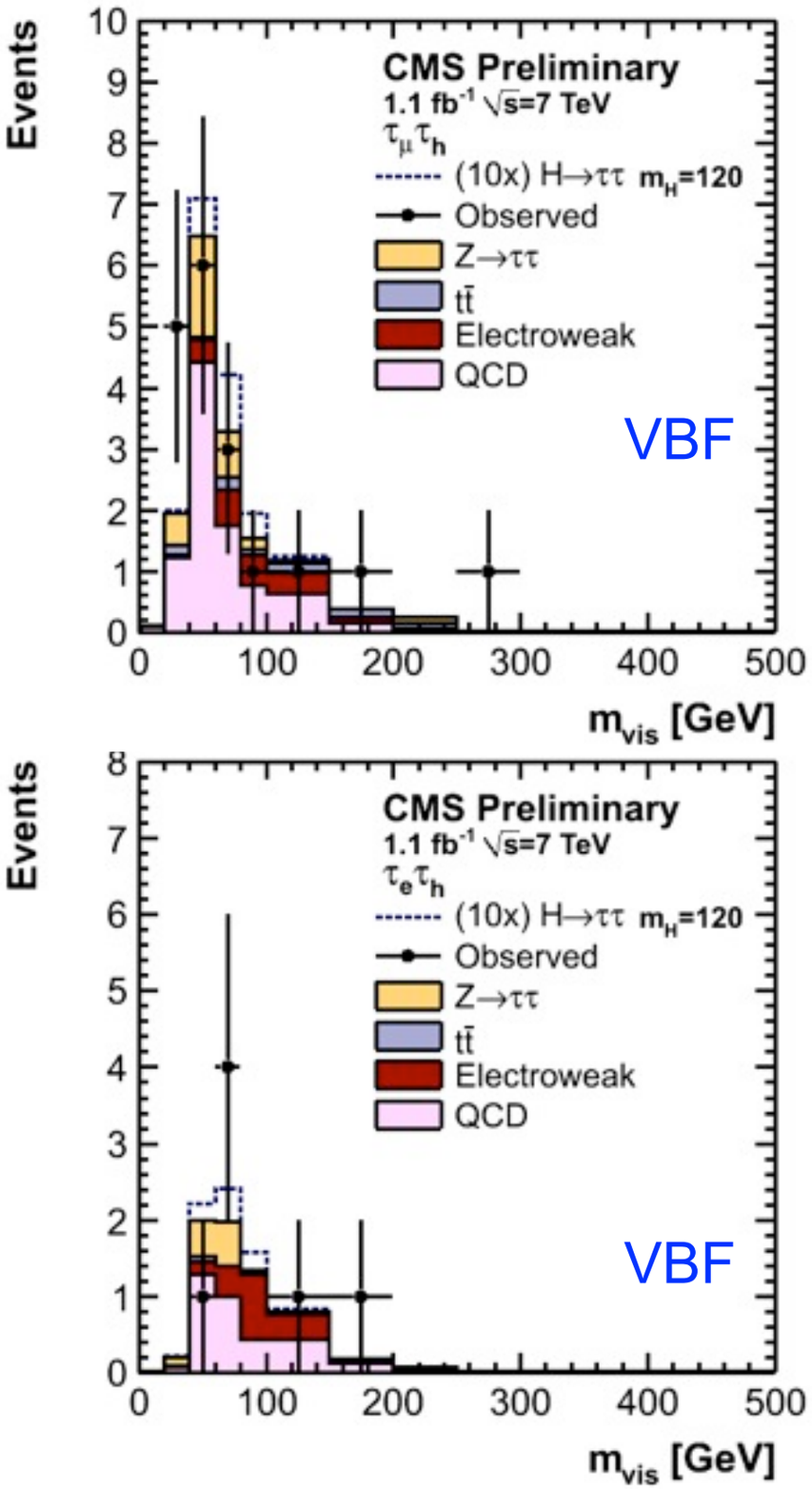




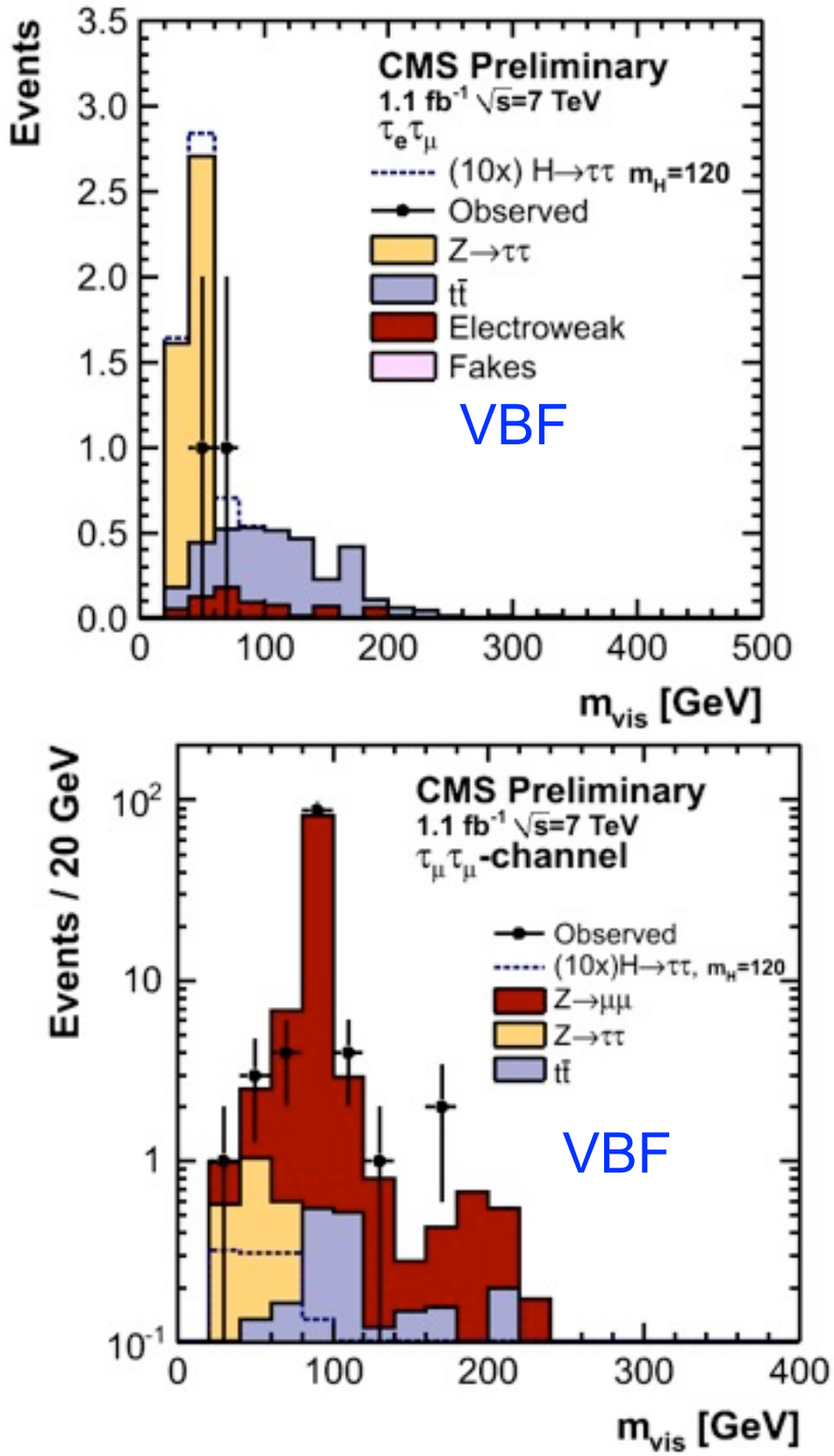

Jet2 pT = 46 GeV
Jet1 pT = 177 GeV
Tau pT = 69 GeV
Muon pT = 20 GeV
MET = 97 GeV
CMS
CMS Experiment at LHC, CERN
Data recorded: Fri May 20 01:10:36 2011 CEST
Run/Event: 165364 / 356120525
Lumi section: 285

VBF

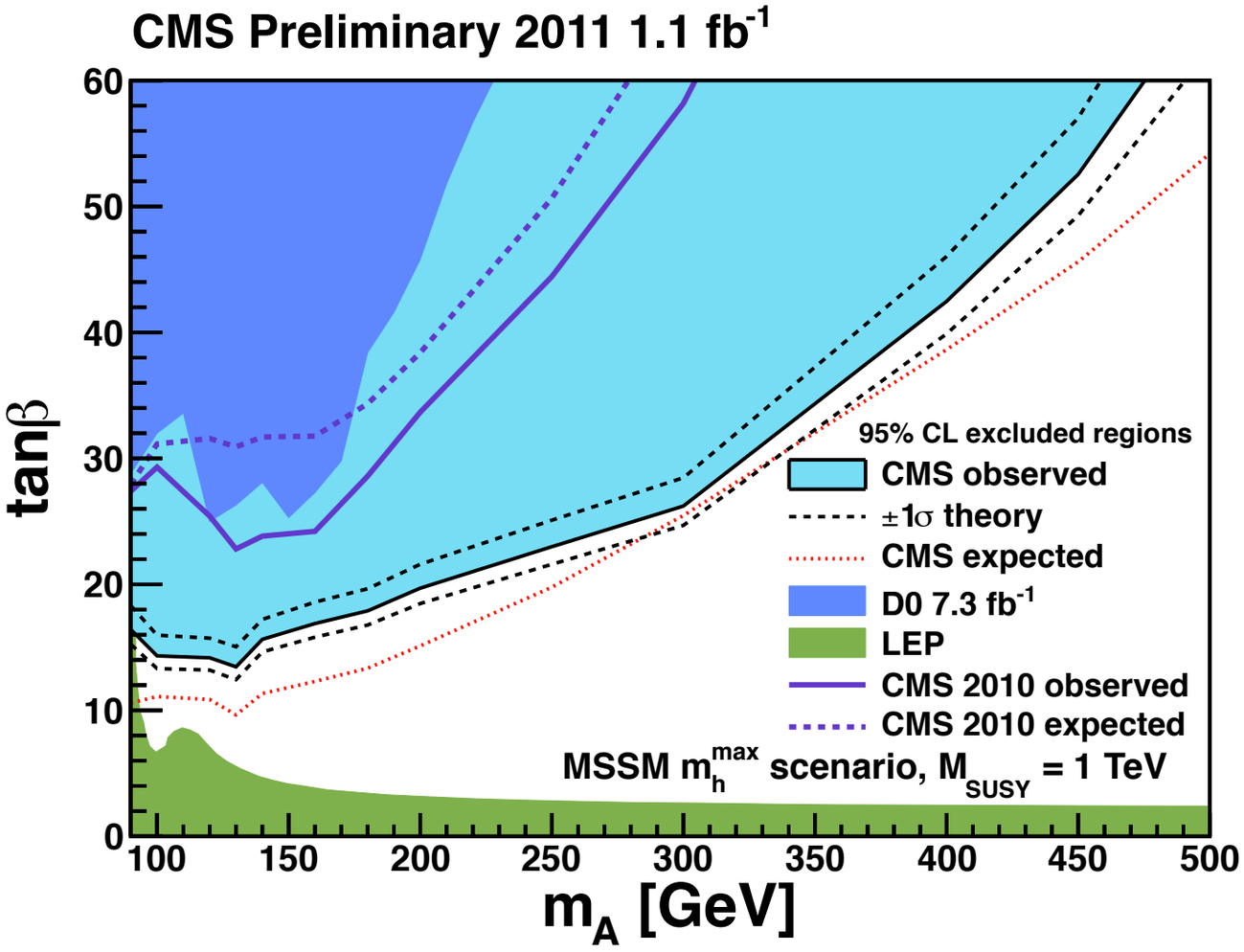
Mass distributions

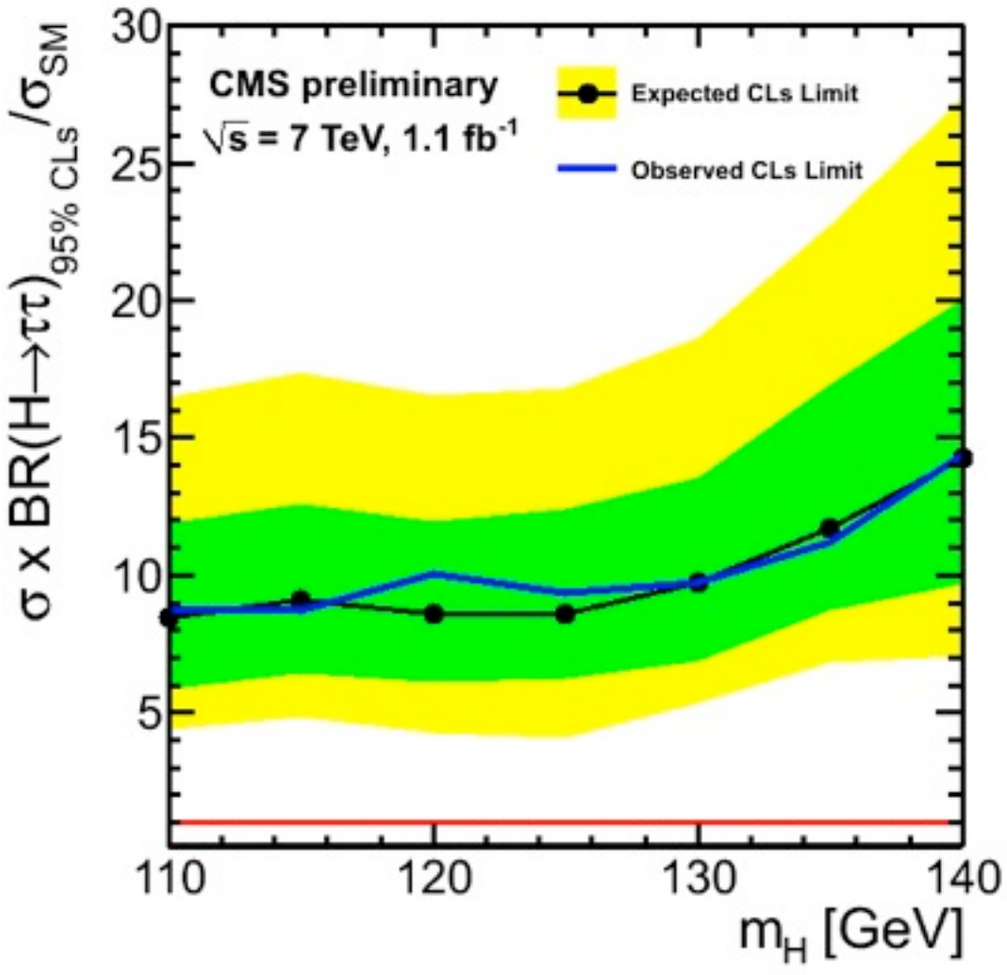


final state	VBF
mu+Tau BKG	14 +- 4
mu+Tau Data	18
e+Tau BKG	5.9 +- 2.5
e+Tau Data	7
e+mu BKG	6.7 +- 1
e+mu Data	2
mu+mu BKG	92 +- 7
mu+mu Data	103



Conclusions





- MSSM limit MUCH improved wrt 2010 data
- First look at the SM limit : SigmaxBR < 10 x Standard Model
  - Doing 1.5x better than what we expected !

Backup

Triggers

- CMS has an advanced trigger system
  - the HLT reconstruction allows a refined selection
    - performance very similar to the offline
      - Tau trigger rely already on the particle flow @ HLT !
- combined triggers looking for pairs of leptons allows to keep the thresholds low even in the presence of high luminosity and PU

Mu+Tau

IsoMuon15 and IsoTau15

Ele+Tau

IsoElectron20 and IsoTau20

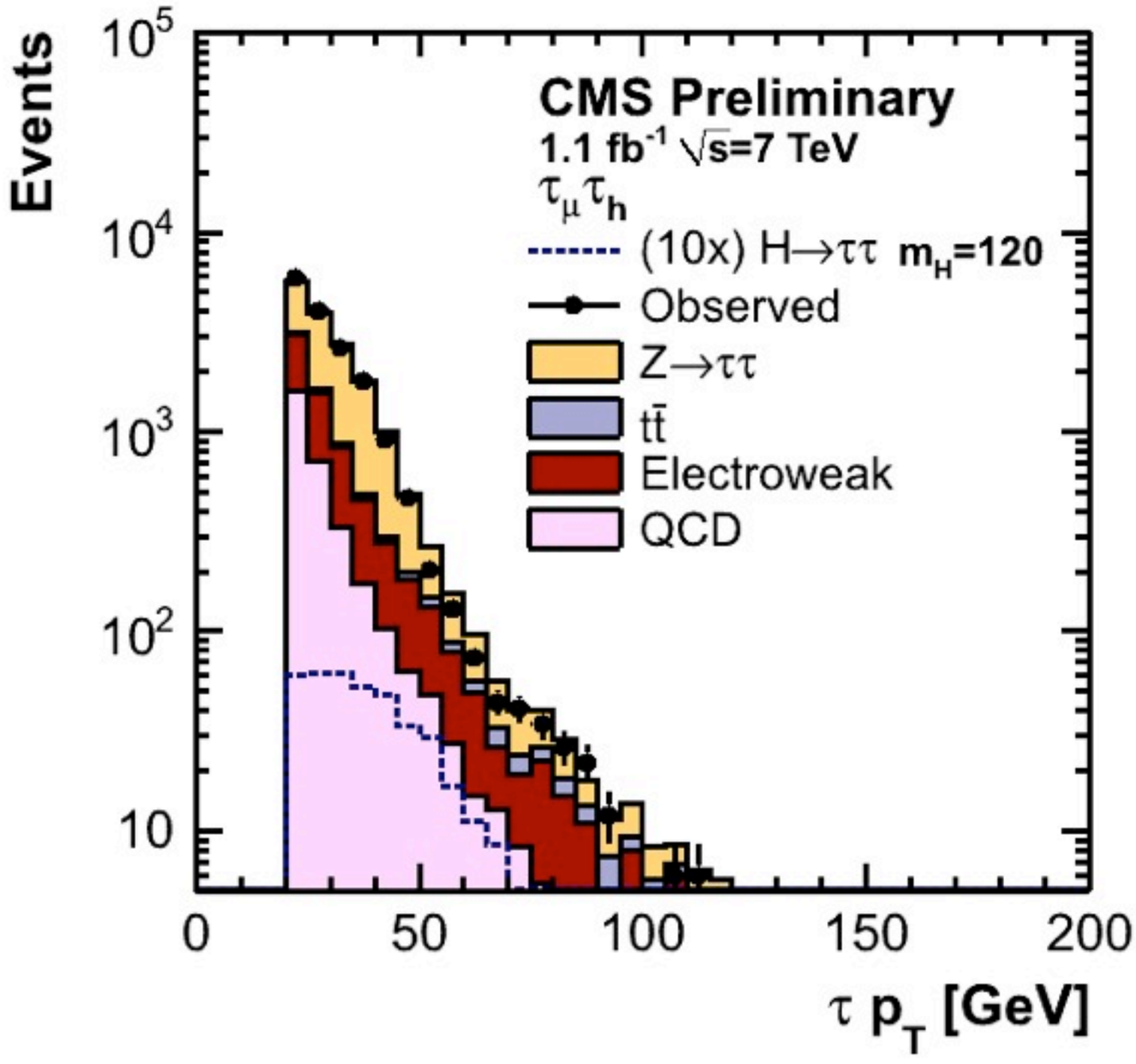
Mu+Ele

Mu8 && Ele17 OR Mu17 && Ele8

Mu+Mu

IsoMu17

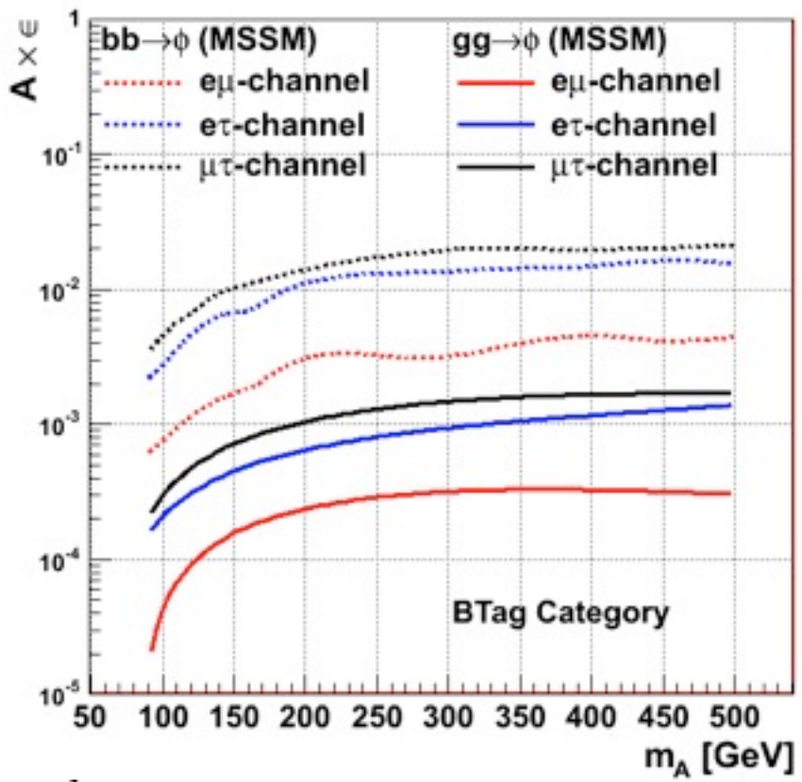
Tau pT distribution

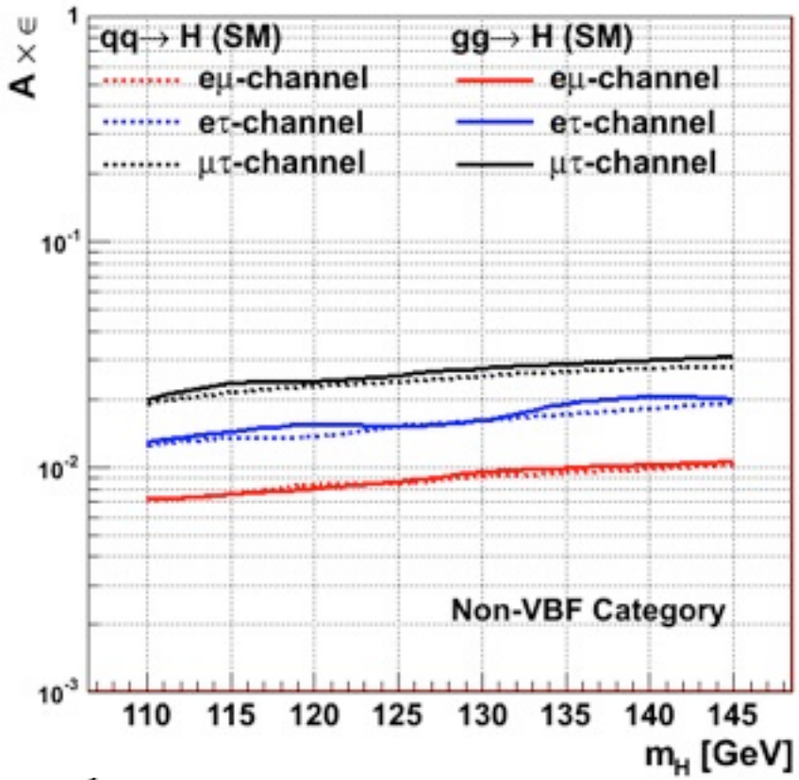


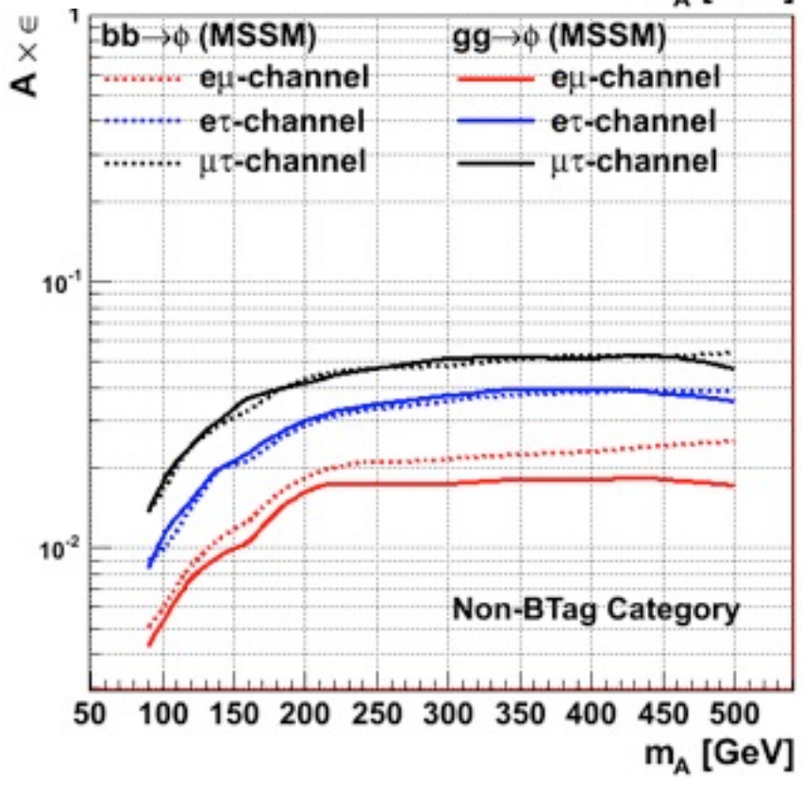
Background estimation

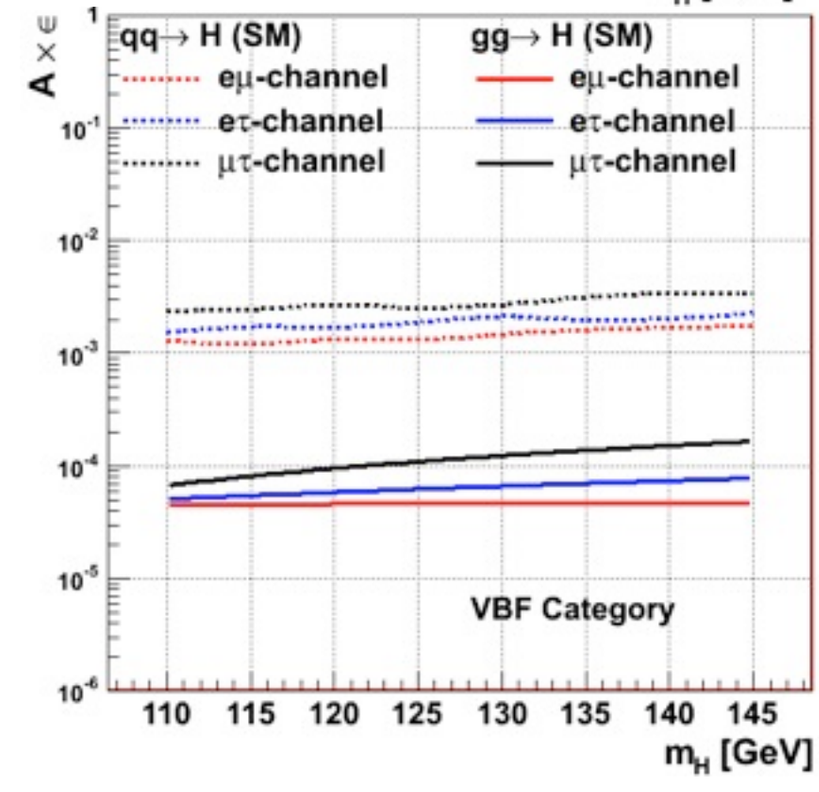
- Z->TauTau
  - MC based shape, with normalization taken from Z->ll CMS measurement (2%)
  - data driven normalization for event categories (using Z->mumu)
- QCD (e+tau and mu+tau)
  - taking SS data and apply correction for OS/SS ratio
    - W+Jets and Z->ll contamination properly subtracted
    - OS/SS ratio measured with single lepton triggers
- W+Jets (e+tau and mu+tau)
  - MC based shape
  - normalization taken from sidebands (reverting the Pzeta cut)
- Fake electrons bkg (for e+mu only)
  - mostly QCD, Z->ll, W+jets. Taken from data using fake rate method
    - uncertainty of 30% used in the fit
- TTbar
  - MC based shape, with normalization taken from CMS measurement
    - 12% uncertainty in the fit
  - data driven normalization for event categories using sidebands
- Di-boson (WW/ZZ/WZ)
  - taken from MC (30% uncertainty in the fit)
- Z->mumu (mu+mu case)
  - bkg normalization and shape taken with sidebands on the Likelihood based variable

Signal acceptance









MSSM limits/channel

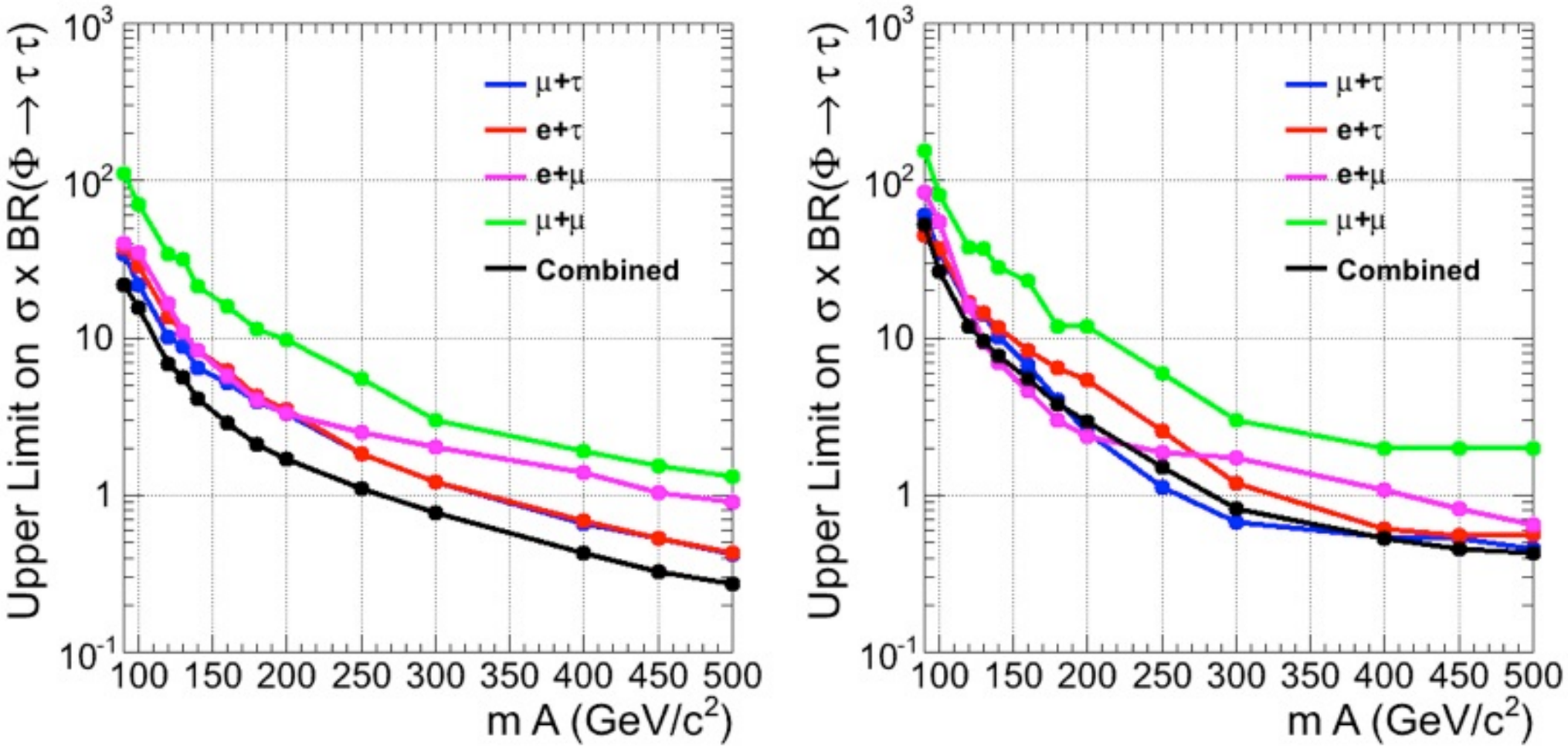


Figure 25: Results for the expected (left) and observed (right) cross section, 95% upper limits, using BTagging for MSSM efficiency model for $\mu + \tau_h$, $e + \tau_h$, $e + \mu$, $\mu\mu$ and combined.

SM limits/channel